Full Length Research Article

© 2024, Centre for Advanced Research in Agricultural Sciences
Research Journal of Agricultural Sciences
Volume 15; Issue 06 (Nov–Dec 2024); pp 1246–1250

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Revival of Alleppey Finger Turmeric (*Curcuma longa* L.) Genotypes in Kerala for Export Purpose

Merlin Abraham*[1], Sunil A. Nair[2], Mini Raj N[3], P. Anitha[4], Vikram H. C.[5] and Sajitha Vijayan M[6]

[1-4] Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Agriculture, Vellanikkara, Kerala Agricultural University, Vellanikkara, Thrissur - 680 656, Kerala, India
[5] Pepper Research Station, Panniyur, Kerala Agricultural University, Vellanikkara, Thrissur - 680 656, Kerala, India
[6] Department of Agricultural Statistics, College of Agriculture, Vellanikkara Kerala Agricultural University, Vellanikkara, Thrissur - 680 656, Kerala, India

Received: 19 Sep 2024; Revised accepted: 08 Nov 2024

Abstract

An investigation was conducted to identify Alleppey Finger Turmeric (AFT) a traded local turmeric genotype cultivated in central districts of Kerala. These genotypes have a consistent demand in the Northern American and European continents due to their natural orange-yellow colour and curcumin content. However, in view of the meagre production of the AFT in the niche areas and its growing demand for export has necessitated identification and purification of existing germplasm. With this background, an investigation was done by evaluating twenty-eight genotypes for evaluation of growth and yield parameters. Wide variation was reported in morphometric and rhizome characters. The highest rhizome yield was obtained in AFT 45 (35.72 tonnes/ha), followed by AFT 21 (32.08 tonnes/ha), AFT 31 (32.04 tonnes/ha) and AFT 12 (31.12 tonnes/ha). Screening of the AFT genotypes revealed seventeen genotypes with zero incidence. High genetic advance and variability were observed in yield and yield contributing characters. The morphometric characters *viz.,* plant height and number of tillers were directly and significantly correlated with rhizome yield. Based on the growth and yield characters, AFT 12, AFT 21, AFT 31 and AFT 45 were found to be promising and can be utilized for future breeding programmes.

***Key words*:** Alleppey finger turmeric, *Curcuma longa* L., Characterization, Correlation, Export, Variability

Turmeric (*Curcuma longa* L.) is one of the major rhizomatous spice crops in India grouped under the Zingiberaceae family. Turmeric boasts of a rich historical significance that stretches back thousands of years in India. It has been used for its colour, flavour, and digestive properties since the Vedic and Biblical periods [1]. India leads the world in turmeric production, consumption and export. It produces 11,69,982 tonnes of turmeric from 3,20,782 hectares of land with Maharashtra, Telangana, and Karnataka being the leading producers [2]. During 2022-23 India exported turmeric worth Rs. 1,87586.79 [3].

India has the largest diversity of turmeric cultivars and Indian turmeric is considered as one of the best on global scale. There are mainly two commercial types of Indian turmeric that are traded to the American continent. These are Alleppey and Madras types and the most preferred one was Alleppey type [4]. AFT is mostly marketed as whole, grounded and extract forms. As per the World Spice Organization and the industry, export specifications for AFT grounded form based on Lab value is orange-yellow colour with a color value of minimum 6000 AST and curcumin content of 5 to 6.5 per cent. This specific trait turmeric is traded from central region of Kerala. The importance of turmeric, specifically Alleppey Finger Turmeric (AFT) grown in central Kerala, is immense in the agricultural export scenario of India. Since the present area and production of Alleppey Finger Turmeric (AFT) is minimal, the exports of AFT is being affected stressing upon rejuvenation of the produce. Therefore, the present research study is imperative in identifying high-yielding and quality AFT genotypes. On identification and purification of the Alleppey Finger Turmeric (AFT) types these could be mass multiplied in the niche areas. Thus, the present study is significant and could play a major role in boosting the economy of the state by cultivating specific AFT types by the farmers.

MATERIALS AND METHODS

In the present scenario, field studies were conducted at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur from July 2023 to March 2024. Twenty-five genotypes of AFT types were collected from niche area of Idukki, Kottayam, Ernakulam, Palakkad, Pathanamthitta and Thrissur which lies in the central part of Kerala. The varieties viz., Kanthi and Shobha, from Kerala Agricultural University and Alleppey Supreme from the Indian Institute of Spices Research, Kozhikode, were used as check varieties to compare the yield and quality attributes vis-a-vis the collected AFT genotypes. The details of the collection of genotypes are mentioned in (Table 1).

***Correspondence to:** Merlin Abraham, E-mail: merlin-2022-12-038@student.kau.in; Tel: +91 7907861685

Citation: Abraham M, Nair SA, Mini Raj N, Anitha P, Vikram HC, Sajitha Vijayan M. 2024. Revival of alleppey finger turmeric (*Curcuma longa* L.) genotypes in Kerala for export purpose. *Res. Jr. Agril. Sci*. 15(6): 1246-1250.

The twenty-eight genotypes were grown in randomized block design (RBD) with two replications. Raised beds of 2 × 1 metre were prepared and healthy seed rhizomes weighing 25 grammes were sown at a spacing of 25 × 25 centimeters accommodating 32 plants per bed. The crop management practices were done as per the Package of Practices Recommendations: Crops of the Kerala Agricultural University 2024 [5]. Morphological observations were recorded at the peak vegetative stage, and the plant and rhizome characters were observed after harvesting as per the minimal descriptor of NBPGR and PPVFRA. Colour analysis of stem, leaf and rhizome was done by Royal Horticulture Society (RHS) colour chart. The per cent disease index was calculated using the score scale of 0 to 9 by examining random fifty leaves [6]. Analysis of variance and other statistical analysis was done using GRAPES and R based software [7].

Table 1 List of AFT genotypes/varieties and place of collection

S. No.	Accessions	Place of collection
1	AFT 11	Palakkad
2	AFT 12	Palakkad
3	AFT 19	Kottayam
4	AFT 21	Palakkad
5	AFT 24	Kottayam
6	AFT 29	Kottayam
7	AFT 31	Kottayam
8	AFT 33A	Ernakulam
9	AFT 35A	Ernakulam
10	AFT 36	Ernakulam
11	AFT 37	Ernakulam
12	AFT 38	Ernakulam
13	AFT 39	Ernakulam
14	AFT 40	Ernakulam
15	AFT 41	Ernakulam
16	AFT 42	Ernakulam
17	AFT 43	Palakkad
18	AFT 44	Idukki
19	AFT 45	Idukki
20	AFT 46	Thrissur
21	AFT 47	Idukki
22	AFT 48	Idukki
23	AFT 49	Idukki
24	AFT 50	Idukki
25	AFT 55	Pathanamthitta
26	Alleppey supreme	IISR, Kozhikode
27	Kanthi	KAU, Thrissur
28	Varna	KAU, Thrissur

RESULTS AND DISCUSSION

Analysis of the data revealed absence of variation in the genotypes in case of qualitative morphological characters such as pseudostem colour, leaf colour on dorsal and ventral side and leaf orientation. However, colour of pseudostem colour was strong yellow green (RHS 144A), leaf colour on dorsal side was moderate yellowish green (RHS 138A), leaf colour on ventral side was moderate yellow green (RHS 138B) and reported leaf orientation was erect. These characters such as pseudostem and leaf lamina colour may be employed as morphological markers for the selection of superior genotypes [8].

Qualitative rhizome characters such as rhizome branching, rhizome nature and inner core colour reported wide variations. Twenty-one per cent of genotypes exhibited straight branching whereas seventy-nine per cent exhibited curved branching. Among the genotypes, forty-three per cent were plumpy and the remaining fifty-seven per cent had slender rhizomes. According to RHS colour chart majority of genotypes except four had strong orange-coloured inner cores and remaining had different variations of yellow (Table 2, Fig 1). Mishra *et al*. [9] reported three colour variations of rhizome inner core such as orange, yellow and red [9]. Recording of the inner core colour is very important because it determines the intensity of colour of turmeric powder meeting consumer specifications.

Table 2 Colour variations detected in genotypes as per RHS colour chart

Genotype	Inner core colour
AFT 11	Strong orange (25 A)
AFT 12	Strong orange (N25 C)
AFT 19	Strong orange (N25 C)
AFT 21	Strong orange (25 A)
AFT 24	Strong orange (N25 C)
AFT 29	Strong orange (N25 B)
AFT 31	Strong orange (N25 A)
AFT 33A	Strong orange yellow (N25 D)
AFT 35A	Strong orange (25 A)
AFT 36	Strong orange (N25 C)
AFT 37	Strong orange (N25 B)
AFT 38	Strong orange (N25 A)
AFT 39	Strong orange (25 A)
AFT 40	Strong orange (N25 A)
AFT 41	Strong orange (N25 C)
AFT 42	Strong orange (N25 B)
AFT 43	Strong orange (N25 A)
AFT 44	Strong orange yellow (17 A)
AFT 45	Strong orange (N25 A)
AFT 46	Strong orange (N25 A)
AFT 47	Strong orange (N25 B)
AFT 48	Strong orange (N25 A)
AFT 49	Vivid orange yellow (23 A)
AFT 50	Vivid orange yellow (21 A)
AFT 55	Strong orange (N25 B)
Alleppey supreme	Strong orange (N25 B)
Kanthi	Strong orange (N25 A)
Varna	Strong orange (N25 A)

Wide variation was reported among the accessions in characters such as plant height, plant girth, number of tillers, number of leaves, leaf length, leaf width and crop duration (Table 3). Genetic makeup of genotypes might be a reason for variability in growth characters. Among the genotypes plant height varied from 90.6 cm to 123.0 cm. Highest plant height was reported in AFT 50 (123.0 cm) followed by AFT 29 (122.6 cm) and AFT 45 (121.1 cm). These results were in line with the findings of Kumar *et al.* [10] wherein plant height ranging from 84.91 to 130.78 cm. AFT 21 reported highest plant girth of 1.95 cm. number of tillers and leaves were highest in AFT 45 which was 6.4 and 8.1 respectively. Highest leaf length was reported in AFT 50 (60.3 cm). but maximum width was in Alleppey Supreme (18.10 cm). So, these observations revealed that AFT 21, AFT 45 and AFT 50 were superior in terms of morphological characters.

Similar to morphological characters, rhizome characters such as length of primary rhizome, number of secondary rhizomes, the weight of secondary rhizome, rhizome weight per plant, average rhizome yield and dry recovery also reported variation (Table 4). These rhizome characters are deemed as the yield contributing factors since rhizome is the economic part of turmeric. Wide variation of rhizome weight ranged from 59.0 g (AFT 47) to 256.5 g (AFT 40) reported in the present study.

Sinkar *et al.* [11] reported similar results with a maximum rhizome weight of 208.92 g and a minimum weight of 48.88 g. Anu and Menon [12] reported highest rhizome yield of 32.33 tonnes/ha in Wayanad turmeric accessions. In this study, the highest rhizome yield was contributed by AFT 45 (35.72 tonnes/ha), followed by AFT 21 (32.08 tonnes/ha), AFT 31 (32.04 tonnes/ha) and AFT 12 (31.12 tonnes/ha). Genotypes were selected based on their rhizome yield [13]. So, these genotypes were the outperformed genotypes based on yield aspects. Compared to other genotypes, these genotypes reported the highest values in growth characters.

Per cent disease index (PDI) relates to the susceptibility of the genotypes to a particular disease. The perusal of the data relating to per cent disease index of leaf blotch reported that the check variety Kanthi (63.22%) attained the highest disease susceptibility followed by Varna (60.10%). Among the genotypes, Alleppey Finger Turmeric (AFT) 40 reported the highest PDI (53.32%). At the same time, among these twenty-eight genotypes, seventeen genotypes reported the absence of leaf blotch disease (Table 3). Similarly, the highest Per cent disease index (PDI) of 51.00 per cent was reported in Wayanad turmeric accessions [12].

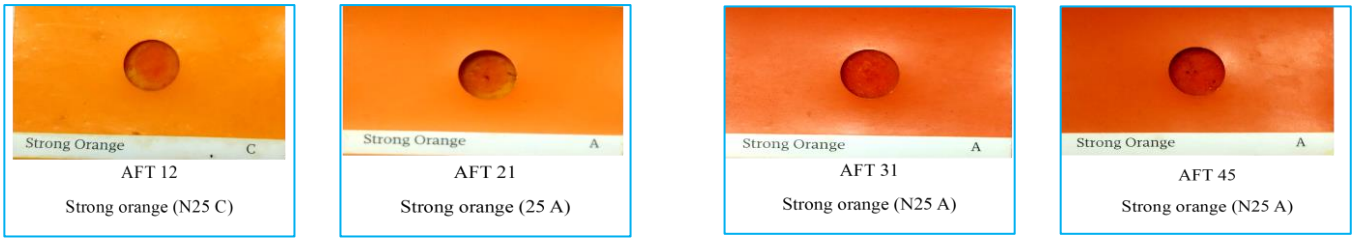

Fig 1 Rhizome inner core colour of promising genotypes using RHS colour chart

Table 3 Qualitative morphological characters of alleppey finger turmeric genotypes

Treatment	Plant height (cm)	Plant girth (cm)	Number of tillers	Number of leaves	Leaf length (cm)	Leaf width (cm)	Crop duration (days)
AFT 11	113.9	1.45	4.8	7.7	51.3	15.05	222.0
AFT 12	113.6	1.85	6.2	7.5	50.4	15.20	222.0
AFT 19	108.2	1.70	6.3	7.2	51.5	16.00	224.0
AFT 21	117.6	1.95	5.6	7.6	53.8	17.20	236.5
AFT 24	105.8	1.43	5.1	6.2	49.1	15.30	214.5
AFT 29	122.6	1.38	5.3	7.3	47.0	15.80	221.0
AFT 31	117.0	1.49	5.7	7.1	43.2	12.80	216.5
AFT 33A	90.7	1.48	5.6	7.4	45.7	13.00	216.0
AFT 35A	103.0	1.57	5.4	7.4	49.1	15.70	219.5
AFT 36	114.8	1.57	5.3	7.9	48.5	13.40	220.0
AFT 37	112.6	1.62	4.5	7.9	53.7	16.15	217.5
AFT 38	108.9	1.68	5.2	6.8	45.0	14.15	196.5
AFT 39	104.3	1.47	5.6	7.5	50.0	14.70	216.5
AFT 40	108.5	1.59	5.0	6.6	49.4	14.70	202.5
AFT 41	98.5	1.39	5.1	7.0	51.0	15.80	212.0
AFT 42	112.4	1.65	4.8	7.4	53.8	14.70	221.0
AFT 43	110.5	1.56	6.0	7.4	46.4	13.50	231.0
AFT 44	112.9	1.51	4.7	6.7	55.6	15.85	220.0
AFT 45	121.1	1.52	6.4	8.1	53.2	17.10	217.5
AFT 46	111.8	1.57	5.7	6.4	51.5	13.70	211.5
AFT 47	98.0	1.43	4.4	6.4	44.4	15.30	233.0
AFT 48	109.0	1.59	5.0	7.1	50.0	14.35	238.0
AFT 49	113.4	1.54	5.1	6.4	51.8	14.80	218.0
AFT 50	123.0	1.89	5.6	8.0	60.3	14.90	235.0
AFT 55	100.1	1.45	5.3	7.3	47.3	14.40	227.5
Alleppey supreme	103.3	1.61	5.4	6.8	52.8	18.10	235.0
Kanthi	90.6	1.26	4.2	6.8	45.7	12.70	207.5
Varna	112.2	1.67	4.1	6.3	44.3	12.20	183.0
SE(m)	1.64	0.05	0.24	0.22	0.96	0.41	2.38
CV (%)	2.13	4.12	6.43	4.27	2.73	3.85	1.54

For an effective response to selection in any genotype there should be genetic variation and high heritability for the characters analyzed [14]. Phenotypic coefficient of variation (PCV) will be always greater than genetic coefficient of variation (GCV). In the present study, the highest PCV and GCV were reported in rhizome weight per plant, which was 30.27 per cent and 29.34 per cent, respectively (Table 5). Average rhizome yield was also reported almost similar GCV and PCV of 29.69 and 27.42 per cent. Heritability was highest for all parameters except dry recovery. Highest genetic advance was observed in the trait rhizome weight per plant (58.60%) followed by average rhizome weight (52.16%). High heritability and genetic advance influence the selection of superior genotypes. Previous studies reported that yield and its yield contributing factors had high heritability and genetic advance [9]. High genetic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV) were reported for rhizome characters. At the same time, morphological characters like plant height, leaf length, leaf width, etc., exhibited lower values [15].

Table 4 Quantitative rhizome characters of Alleppey finger turmeric genotypes

Treatment	Length of primary rhizome (cm)	Width of primary rhizome (cm)	Internodal length (cm)	Rhizome weight per plant (g)	Average rhizome yield (tonnes ha^{-1})	Dry recovery (%)	PDI (%)
AFT 11	6.29	1.88	0.76	109.5	21.76	26.09	0.00 (4.06)^{g}
AFT 12	6.45	**2.29**	0.80	226.5	31.12	22.46	0.00 (4.06)^{g}
AFT 19	6.24	2.24	0.83	166.5	26.64	21.75	0.00 (4.06)^{g}
AFT 21	7.82	2.13	1.22	189.0	32.08	19.27	0.00 (4.06)^{g}
AFT 24	5.72	1.84	0.83	109.0	17.96	24.72	28.44 (32.23)^{e}
AFT 29	6.08	2.11	0.76	172.5	28.84	22.87	0.00 (4.06)^{g}
AFT 31	6.07	2.10	0.73	196.0	32.04	20.24	23.11 (28.73)^{f}
AFT 33A	7.33	1.40	0.84	186.5	25.46	26.10	0.00 (4.06)^{g}
AFT 35A	5.05	1.93	0.75	117.5	15.48	24.06	0.00 (4.06)^{g}
AFT 36	6.90	1.57	0.84	202.0	27.86	23.82	31.66 (34.23)^{e}
AFT 37	5.92	1.86	0.72	203.5	23.20	23.41	0.00 (4.06)^{g}
AFT 38	7.2	1.60	0.80	184.0	23.64	23.58	40.99 (39.81)^{d}
AFT 39	6.61	1.79	0.83	132.0	20.20	23.22	0.00 (4.06)^{g}
AFT 40	9.33	1.47	**1.25**	256.5	28.20	23.18	53.32 (46.91)^{b}
AFT 41	6.66	1.57	0.83	94.5	16.24	22.80	0.00 (4.06)^{g}
AFT 42	5.71	1.66	1.02	143.0	24.94	23.40	0.00 (4.06)^{g}
AFT 43	8.43	1.99	1.06	199.0	30.28	20.86	46.33 (42.89)^{c}
AFT 44	5.86	1.56	0.72	124.5	20.40	24.95	45.55 (42.45)^{c}
AFT 45	6.77	1.52	0.78	175.0	35.72	21.77	0.00 (4.06)^{g}
AFT 46	5.99	1.61	0.85	85.5	20.38	25.35	0.00 (4.06)^{g}
AFT 47	4.82	**1.20**	**0.56**	59.0	5.84	25.21	0.00 (4.06)^{g}
AFT 48	6.28	1.27	0.71	114.5	12.32	20.16	0.00 (4.06)^{g}
AFT 49	8.04	1.52	0.92	182.0	23.48	22.86	49.10 (44.49)^{c}
AFT 50	7.60	1.69	1.10	220.0	23.08	23.18	46.88 (43.22)^{c}
AFT 55	6.49	1.55	0.82	142.0	15.88	24.23	0.00 (4.06)^{g}
Alleppey supreme	5.63	1.75	1.17	172.0	19.66	20.95	0.00 (4.06)^{g}
Kanthi	8.96	1.50	1.08	190.0	21.46	23.36	63.22 (52.70)^{a}
Varna	7.86	1.67	0.93	231.0	22.62	22.28	60.10 (50.84)^{a}
SE(m)	0.20	0.03	0.03	8.59	1.86	0.91	0.794
CV (%)	4.23	2.31	3.98	7.43	11.39	5.60	2.303

Figures in parenthesis are the arc sine transformation

Table 5 Variability analysis of AFT genotypes

Characters	Mean	CV (%)	PCV (%)	GCV (%)	Heritability	Genetic advance (%) (i=5%)
Plant height	109.22	2.13	7.84	7.55	92.64	14.96
Plant girth	1.57	4.04	10.20	9.37	88.61	17.72
Number of tillers	5.30	6.44	12.13	10.28	71.74	17.93
Number of leaves	7.15	4.27	8.19	6.99	72.89	12.30
Leaf length	48.24	2.73	8.09	7.61	88.61	14.76
Leaf width	14.88	3.86	9.87	9.09	84.74	17.23
Crop duration	219.11	1.54	5.66	5.45	92.63	10.81
Length of primary rhizome	6.72	4.24	16.85	16.31	93.68	32.53
Width of primary rhizome	1.72	2.60	16.48	16.28	94.05	33.11
Internodal length	0.87	3.62	19.51	19.17	96.55	38.80
Rhizome weight per plant	163.68	7.43	30.27	29.34	93.98	58.60
Average rhizome yield	23.10	11.39	29.69	27.42	85.28	52.16
Dry recovery	23.09	5.60	8.55	6.47	57.19	10.08

Pearson's simple correlation analysis revealed significant relations between different character in AFT genotypes (Table 6). In the present study, average rhizome yield was significantly and directly correlated with plant height (0.56**), number of tillers (0.54**), rhizome weight per plant (0.71***), length of rhizome (0.43*), width of rhizome (0.53**). It indicated that high yielding varieties can be selected based on these morphological traits. Previous studies were also pointed out the significance of plant height and number of tillers in high yielding genotype selection due to its positive significant correlation with rhizome yield [16-17]. Similarly, another study reported the positive correlation of rhizome weight, length and width of primary rhizome with rhizome yield [18]. Conversely, rhizome weight and average yield was negatively correlated with crop duration. It was already reported that varieties that mature early had higher productivity and late varieties had lower productivity [19]. These findings suggest that high-yielding varieties can be effectively selected based on these traits. Consistent with previous research, traits like plant height, tiller number, and rhizome characteristics (weight, length, width) positively influence yield, while longer crop duration negatively impacts productivity, reinforcing the advantage of early-maturing varieties for higher yields.

Table 6 Pearson's correlation analysis of morphological characters

	Plant height	Plant girth	Number of tillers	Leaf width	Crop duration	Rhizome length	Rhizome width	Rhizome weight	Average yield
Plant height	1								
Plant girth	0.50**	1							
No. of tillers	0.30	0.35	1						
Leaf width	0.22	0.24	0.26	1					
Crop duration	0.12	0.21	0.34	0.48**	1				
Rhizome length	-0.01	0.12	-0.03	-0.34*	-0.33	1			
Rhizome width	0.41*	0.37	0.48*	0.23	0.12	-0.11	1		
Rhizome weight	0.32	0.44*	0.14	-0.20	-0.27	0.67***	0.28	1	
Average yield	0.56**	0.35	0.54**	0.01	-0.13	0.43*	0.53**	0.71***	1

***Correlation is significant at 0.001 level (Two tailed)
**Correlation is significant at 0.01 level (Two tailed)
*Correlation is significant at 0.01 level (Two tailed)

CONCLUSION

The present study was instrumental in locating the niche areas for cultivation of Alleppey Finger Turmeric genotypes. The research studies are also first of its kind in identifying AFT genotypes as per the export specifications. In view of the wide variations in growth, yield and quality characters, it is also observed that there is more than one genotype that can be classified under the umbrella of Alleppey Finger Turmeric (AFT). High genetic advance and variability was observed in yield and yield contributing characters such as rhizome yield, rhizome weight per plant, length, width and internodal length of primary rhizome. Also, these characters along with plant height and number of tillers were directly and significantly correlated with rhizome yield. So, these traits can be utilized as selection criteria for superior genotypes. Genotypes such as AFT 12, AFT 21, AFT 31, and AFT 45 are thus recommended for their superior yield and core colour characters. However, these need to be further validated based on biochemical and molecular characterization. As primary studies the identified genotypes may serve as tools for future genetic enhancement and breeding programmes.

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